Measurement of Floating Petroleum Product Thickness and Determination of Hydrostatic Head in Monitoring Wells

Leaking underground petroleum storage tanks are frequently encountered on military installations. Numerous hydrogeologic investigations are presently being conducted to delineate problems associated with soil and water contamination at these sites. Proper design of remedial systems depends upon the accurate characterization of the fate and distribution of the contaminants as they interact with the soil and ground water. The measurement of petroleum product thickness and the determination of hydrostatic (piezometric) head in monitoring wells are useful parameters to someone interested in designing a remediation scheme. Piezometric surface data leads to the determination of the hydrogeologic gradient, (or more importantly, the approximate migration rate and direction of the mobile component(s) of the contaminant in the subsurface environment) while product thickness data may lead to an estimate of product volume (total amount released at the site). Before one can begin designing a remediation scheme for subsurface hydrocarbon removal, there are a few points about monitoring well fluid level measurement and interpretation that require understanding.

Many assume that petroleum product thicknesses measured in monitoring wells can be used to determine product volume in the ground. Since there are so many variables that influence product thickness in the well (most importantly capillarity), one must remember that this measured thickness is an apparent thickness and must be adjusted accordingly (Hampton, 1989; Lenhard and Parker, 1990). Also, simple comparisons of product thickness variations over time do not necessarily reflect significant changes in volume of product in the vicinity of the well. These variations may be due to groundwater migration, lunar influences, or even tidal effects (in coastal regions). Likewise, a well in one portion of a site that has a product thickness much larger (greater than 50%) than the thickness measured in a well located in another portion of the site does not necessarily mean that there is more product in the vicinity of the well exhibiting the larger thickness. These product thickness differences are often due to hydrogeologic heterogeneity. These are very important concepts that must be understood by regulatory personnel and those in the environmental and engineering field divisions.

When determining hydrostatic head in wells that exhibit floating petroleum product, it is common practice to measure the product thickness in the well (apparent thickness), apply a correction factor (to account for density differences between water and product), and add this modified thickness value to the value obtained for the depth of the water/product interface. There are inherent problems associated with this approach. While most investigators use

a correction factor between 0.75 and 0.80 for gasoline (density range for most gasolines), this value may change through time due to contaminant phase partitioning, fractionation, and dispersion. Also, it has long been suspected that grain size distribution and hydraulic conductivity dictate the relationship between apparent product thickness in the well and the corresponding contaminated capillary zone thickness adjacent to the well (what one really needs to determine).

Hampton (1989) evaluated several literature equations that relate the apparent thickness in a well to the actual thickness of the layer of mobile product in a contaminated aquifer. He concluded that apparent product thickness greatly exceeds the actual thickness, although attempts to relate these quantities by subtracting the capillary fringe thickness as suggested by Hall et al (1984) and Schiegg (1985) or by dividing by a constant factor (usually around 4) as suggested by de Pastrovich et al (1979) were unsatisfactory. It is important to note that the well known but poorly understood de Pastrovich rule of thumb ignores aquifer material properties and assumes an oil density of 0.8 times that of water (not too bad for gasoline in homogeneous sand, but may cause problems for hydrocarbons that have different densities or that have been altered). In actuality, this factor can vary from 2 to 24 depending upon the product density and the aquifer material.

A personal computer software package (OILEQUIL) based on multiphase saturation-pressure relationships derived by Parker and Lenhard appears to be the best choice for the determination of the ratio of apparent versus actual thickness (Hampton, 1989). In general, however, the equilibrium apparent thickness exceeds the actual thickness more than is predicted by these equations. Therefore, hydrologists and engineers must realize that no simple relationship between real and apparent thicknesses always applies. It is imperative that environmental professionals keep abreast of new developments in these areas.

An acceptable approach to designing a remediation scheme for a site exposed to subsurface petroleum contamination in which one has monitoring well data is as follows:

- Correct piezometric surface measurements for density differences between the contaminants and water.

- Geostatistically treat these values with krige methodology and contour capacity software (i.e., EPAs GeoEAS program) and plot contoured results for product thickness and piezometric surface.

- Determine the most probable gradient direction(s) and magnitude(s).

- Monitor over time (and determine whether or not geology influences variations in product thickness and piezometric surface).

- Determine hydrodynamic properties of the site (i.e., hydraulic conductivity) and be certain that the remediation method(s) of choice is (are) compatible with site hydrogeology.

- Design the remediation system so that modifications (location of pumps, rate of extraction/injection, etc.) can be easily implemented if further monitoring warrants. For example, if one desires a pumping rate of 10 gallons per minute, use a pump capable of twice that rate (the "two times over-engineering" rule of thumb).

These important points have been under intense scrutiny by leading environmental scientists for at least a decade and there is still no clearcut resolution. The problems associated with hydrogeologic and engineering decisions based upon faulty interpretations of monitoring well data in areas contaminated with subsurface petroleum will continue unless people are introduced to the concepts outlined above and they learn to interpret data with a "grain of salt" approach. For further information contact Mark Kram, NEESA-112E2, AUTOVON 551-2669 or commercial (805) 982-2669.